[illegible]
[illegible]

Lewis G. Ball, Photographer, Crawley

A Curious Ice Structure. (See p. 44.)

M.O. 313.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 64
Mar. 1929
No. 758

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The Cold Spell during February and early March, 1929

By J. Crichton, M.A., B.Sc.

On February 3rd the cold wave over Europe extended its influence over eastern England, the attack, however, not becoming severe until the night of the 10th to the 11th. On the morning of the 11th the temperature at Kew in the shade at 7 a.m. was 29°F., and this had fallen to 27°F. by 1 p.m.; at Folkestone the maximum day temperature was only 23°F.; snow fell in many parts of eastern Scotland, England, northern Wales and northern Ireland. From this date onwards to the 20th, large tracts of Great Britain experienced continuous shade temperatures, both day and night, below 32°F. At 10 p.m. on Sunday, the 10th, the thermometer in the screen went below 32°F. at Kew and remained continuously below that figure until shortly after mid-day on the 17th, a period of just over 158 hours. At Manston similar but more severe conditions prevailed; here the temperature went below 32°F. at 11 p.m. on the 10th, and did not reach it again until 9 a.m. on the 20th, a period of no less than 226 hours continuous frost. On the 20th the thermometer generally rose to or exceeded 32°F. over most of the British Isles.

During the period from the 10th to the 20th the frosts were very severe, and these coupled with the recurrence of snow greatly interfered with the normal life of the nation as a whole. Roads were blocked and impassable in parts of Scotland, Wales

(83328) P.S. 1602/81. 1,000 3/29 M. & S. Gp. 303.

and southwest England, and it was not until the 23rd that the Royal Automobile Club declared that all roads were open to traffic. Thousands of homes were affected throughout the country through their domestic water supplies becoming frozen and many deaths were reported through the bursting of kitchen boilers. The rivers in many parts of the country became frozen over, and ice-breakers were used in the Thames in an endeavour to keep the water open for traffic. This was not, however, entirely successful, many of the upper reaches being frozen over for considerable stretches. On the reach of the Thames above Benson Lock (near Wallingford) on the 17th the river was frozen over for a mile, and more than fifty people were on the ice there in the afternoon, and it was possible to walk across from bank to bank. Canals and lakes were also generally frozen over, and on Lake Windermere there were as many as fifty thousand people on the ice at one time. Skating has not been so frequent since at least 1895.

TABLE I.

Station.	Lowest Minimum.	Date.	Lowest Grass Minimum.	Date.	No. of ground frosts.
	°F.		°F.		
Aberdeen	15	14	3	14	17
Renfrew	11	15	6	15, 16	19
Leuchars	10	16	6	14	22
Newcastle	11	14	9	14	23
Chester	12	15	7	15	22
Birmingham	13	14	−2	15*	26
Ross-on-Wye	−1	14	−8	14†	22
Oxford	10	15	0	16	28
Manchester	7	15	0	15	26
South Farnborough	5	15	−1	15	27
London: Kew	13	15	4	15	26
London: Greenwich	12	15	4	15	28
London: Hampstead	9	15	−2	15	29
Cardington	11	14	8	14	27
Manston	14	15	9	15	26
Lympne	8	15	5	15	27

* Also −1° on 14th. † Also −6° on 13th and −4° on 15th.

At Ross-on-Wye the temperature of −1°F. in the screen was the lowest for at least 70 years, while that at Greenwich of 12°F. on the 15th was the lowest in February since 1895, 7°F. occurring in that year.

Great Britain only shared the cold wave, it was general over most of Europe, blizzards being frequent on the Riviera, snow storms with very low temperatures occurring as far south as Greece and Arctic conditions being experienced in the Black Sea.

In Venice the canals were frozen over, and after a fall of rain at Siwa Oasis the ground became covered with ice.

The Times on March 1st contained the following paragraph :—"Sir Arthur Steel Maitland, the Minister of Labour, in a written reply to Sir John Power, M.P., states :—It is estimated that the recent severe weather caused an increase in the number of persons on the registers of employment exchanges in Great Britain of between 140,000 and 150,000." In connexion with this statement Table I shows the lowest minimum temperatures in the screen and on the grass together with the number of ground frosts between February 4th and March 5th (both days inclusive), a period of 30 days, for various stations in the British Isles. The table illustrates the continuity of the night frosts which were unusually severe. The stations are representative of their neighbourhood, but are not taken as being the lowest in any record sense.

In Table II the mean temperature at a few selected stations has been taken out for February, 1929, the mean being $\frac{1}{2}$ (maximum + minimum).

TABLE II.

Station		Mean Temperature °F	Station		Mean Temperature °F
Lympne	...	31·1	Leuchars	...	33·9
Manston	...	31·5	Chester	...	34·2
Cardington	..	32·3	Aberdeen	...	35·3
Winchester	...	32·3	Valentia	...	45·3
Kew...	...	33·0			

As an illustration of how meteorological records were affected the following details concerning the R.A.F. meteorological station at Leuchars, near St. Andrews, are of interest :—

Lowest day maximum, 26°F., 9 degrees lower than previous February lowest.

Lowest grass minimum, 6°F., 8 degrees lower than previous February lowest.

Mean maximum, 38.1°F., lowest in any month.

Mean minimum, 29.6°F., lowest in any February.

Absolute minimum, 10°F., lowest in any month.

Leuchars has a record of less than 10 years, and thus a comparison cannot be made with previous severe winters.

In February, 1917, in the screen −4°F. was registered at Benson and −3°F. at Wellington, Shropshire, but February, 1917, was not so cold on the whole as that of 1929; February, 1895, was, however, distinctly colder. In Fig. 1 diagrams, representing mean temperatures at four stations in eastern coastal districts and four in the west, are shown for both February, 1895 and 1929. Each diagram brings out clearly that 1895 was during the first 10 or 11 days distinctly colder than 1929. In the west at Scilly, Birr Castle and Stornoway,

MEAN DAILY TEMPERATURES, FEBRUARY, 1895 AND 1929
[$\frac{1}{2}$(MAXIMUM + MINIMUM)].

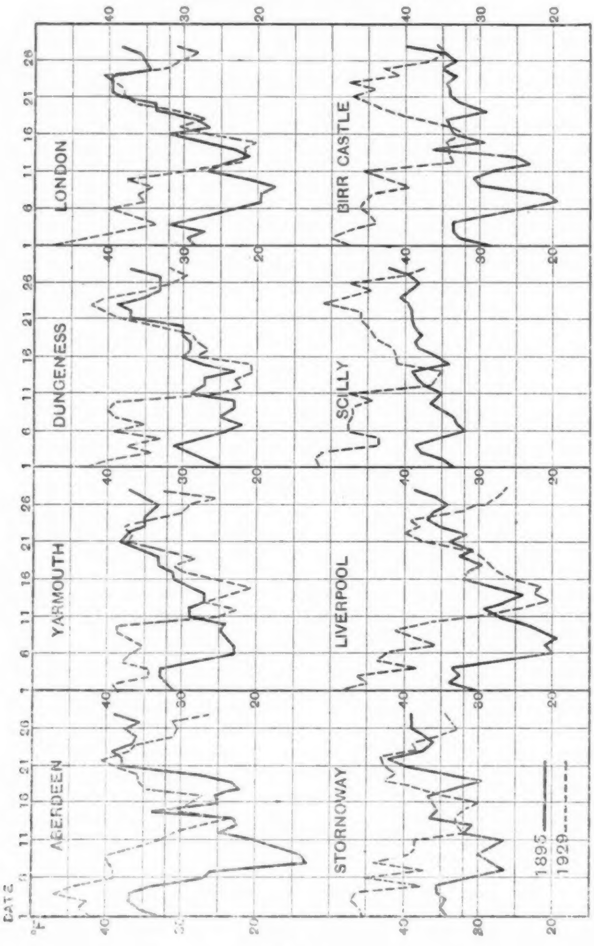

Fig. 1.

1895 practically remains colder throughout the month, Scilly and Birr Castle being distinctly milder in 1929. At Kew, Dungeness, Yarmouth and Liverpool between the 11th and 20th

UPPER AIR TEMPERATURES, FEBRUARY, 1929.

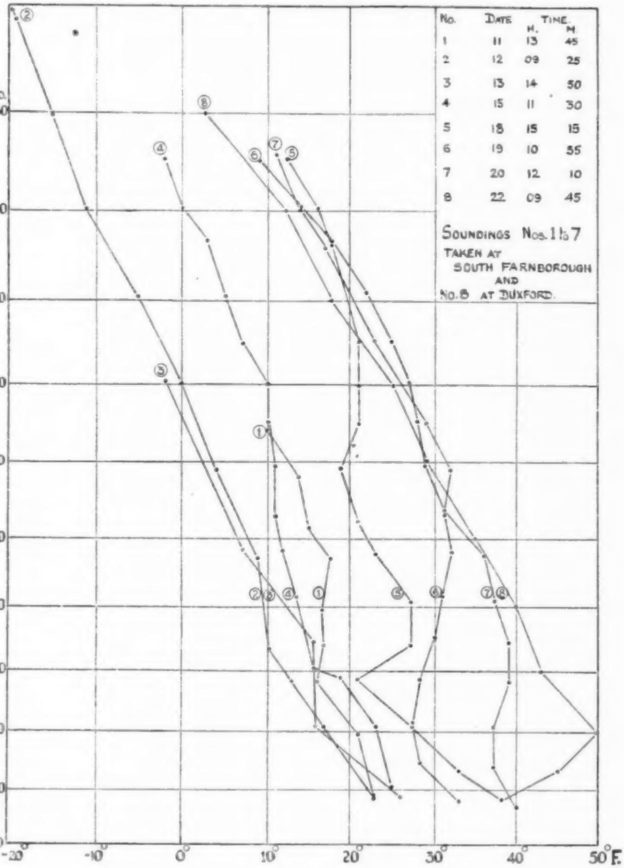

FIG. 2.

the curves are very similar in both years, Dungeness, Yarmouth and Liverpool being if anything colder in 1929 than in 1895. A return of the cold wave about the 24th in 1929 brought lower mean temperatures than in 1895 to most of the stations, and this cold spell lasted for about a week. Thereafter, until March 5th, the two years were once more very similar, during this period

1895 being perhaps the colder. The horizontal line in each diagram is drawn through 32°F., the freezing point of water, and the intersections of this line and the curves brings out very clearly the period of continuous frost both by day and by night.

A good series of upper air temperatures is illustrated in Fig. 2, the readings of pressure and temperature being obtained by means of aeroplane ascents, the ascents are numbered from 1 to 8 in accordance with the dates on which they were made.

Ascent 1 shows a cold air layer to 2,650ft., and then an isothermal one to 5,480ft., after which the temperatures follow the ordinary lapse rate. In ascent 2 the isothermal layer is raised approximately 1,000ft., and its thickness decreased by about the same amount. Ascent 3 indicates a new supply of cold air; there is an isothermal layer here from 1,900ft. to 3,800ft. Ascent 4 has an isothermal layer from 5,600ft. to 9,500ft., and indicates the gradual rise in temperature in the upper layers, this being continued and extended downwards through ascents 5 to 8. In ascent 8 this reaches down to 2,000ft., there being a sharp inversion from the surface to this level. Through the sun's heating of this lower layer a temporary thaw was brought to England. A renewed sweep of cold continental air soon reduced temperatures from the surface upwards.

In conclusion, upon examination of the Greenwich mean temperature records from 1841 for the winter months December to February, only five previous winters prove colder than that of 1928-9. The winter of 1890-1 was the coldest with a mean temperature of 34·1°F., 5·4°F. below the normal. In 1928-9 the mean temperature was 35·2°F., 4·3°F. below the winter normal and only 1·1°F. warmer than 1890-1.

The Structure of Depressions

At the meeting of the Royal Meteorological Society on February 20th described on p. 42, the paper by C. K. M. Douglas and the resulting discussion, were of great interest in providing an insight into the most modern ideas on the structure of barometric depressions. The following sketch represents an attempt by an inexpert member of the audience to set out the impressions which he gained.

A little preliminary explanation may be helpful. The earliest idea of a depression, then known as a cyclone, was simply a column of warm moist rotating air, the warmth and moisture providing the low pressure, and the ascent of air the precipitation. This idea is probably essentially correct for tropical cyclones, but has long been known to be inadequate for those of temperate latitudes. For one thing, the amount of actual

rotation of air about the centre is often relatively small, and the practice accordingly grew up of giving these weak and sometimes irregularly shaped "cyclones" the non-committal name of "barometric depressions." So far their structure was known only at the surface; when the study of their solid structure began, other difficulties appeared. The late Mr. W. H. Dines showed that in this country at least the air in a depression, from a short distance above the surface to a height of ten kilometres or so, was on the average not warm but cold, and in a well-known diagram he attributed the source of the low pressure to a column of warm air in the stratosphere. For convenience we may term this symmetrical depression with cold air below and warm air above the "Dines depression." Similarly the high pressure of anticyclones was attributed to a column of cold air in the stratosphere.

W. H. Dines's idea of the structure of anticyclones has held the field, as far as concerns the great slow-moving anticyclones of long duration which wander into temperate latitudes from sub-tropical regions. There seems little doubt that these are really due to pieces of the high cold stratosphere of low latitudes. Beneath the stratosphere the air is slowly descending and is warmed by compression; hence in the troposphere the air of an anticyclone is warm. The more rapidly moving anticyclones which separate successive depressions have a different structure, and are formed in cold polar air. The theory of depressions on the other hand has undergone great changes, due mainly to the investigations initiated in Norway. According to the well-known diagrams of Bjerknes and Solberg, depressions originate at a wave front between a stream of cold "polar" air moving from the east and a stream of warm "equatorial" air moving from the west. A tongue of equatorial air penetrates the polar air, rising above it along a sloping surface known as the "warm front," while a wedge of polar air cuts into the rear of the warm air along the "cold front." The cold front gradually approaches and finally overtakes the warm front, at which stage the warm air is lifted bodily off the surface and is said to be "occluded." Finally the mass of warm air disappears entirely, and there is left only a whirl of polar air. These ideas were elaborated entirely from the study of surface observations and clouds, and are apparently in direct conflict with the results obtained by W. H. Dines, for they give to the depression a warm centre.

Two results follow immediately from the Norwegian conception of the depression. The first is that rain and snow are formed mainly along the "fronts," and subsequent investigations have shown that there is in fact a very close relationship between rain and fronts. The second inference is that a depression should continue to grow in intensity while there is a warm

sector at the surface, but that after it is occluded its intensity should decrease, and this does not always hold. A depression with a warm sector does not always grow deeper, and an occluded depression sometimes intensifies when it should be filling up. Other difficulties were explained at the meeting. There should be an east wind on the northern side of the future depression, but it appears that as a rule the east wind does not develop until after the depression has formed. Moreover depressions develop in different ways, sometimes without the agency of equatorial air at all, and in fact the only thing which all depressions have in common is a centre of low pressure.

The Dines depression represents the average conditions found in a large number of depressions investigated by sounding balloons in this country, and there is no doubt that as an average it is substantially correct. On the other hand depressions are occasionally found in which the low pressure is actually due to warm air in the lower layers of the troposphere. In one example quoted in the paper pressure fell 12mb. at the surface as the centre approached, while at a height of 4km. it fell hardly at all, and at still higher levels pressure must have risen. The structure of this typical Bjerknes depression was the direct opposite of the Dines depression. The tentative explanation suggested for the contradiction was that the Dines depression was a late stage, which had been reached by the majority of those reaching the British Isles. The difficulties were that there was no obvious way in which the change over from warm air below to warm air above could take place, and that the theoretically dying depressions sometimes continued to grow in intensity.

A way out of both difficulties is given in section 3 of Douglas's paper, based on the circumstance that a very favourable condition for the deepening of a depression is the occurrence of a pronounced polar current behind it. At the surface such a current may be travelling from due north to south, but owing to the general fall of temperature from low to high latitudes there is always a tendency for air at high levels to move from west to east, to some extent independently of fronts. This tendency is especially strong at the upper boundary of the warm sector, at a height of 9km. or so, the height which Dines regarded as specially important. Hence at about this level the polar current, due north at the surface, has a large component towards the east. It over-runs the centre of the depression, and brings with it part of the low warm stratosphere belonging to the polar air. In the lower troposphere warm air is being slowly eliminated, with a consequent tendency for pressure to rise, but at the same time the stratosphere is becoming much warmer, with a tendency for pressure to fall. When the latter tendency predominates, the depression continues to deepen, in spite of

being occluded. The complete depression is therefore a complex affair, due to the superposition of a high-level element above a low-level element. One gathers that the arrival of the high-level depression is not adventitious, but that it must be related to the energy supplied by the juxtaposition of warm and cold air in the lower layers.

Captain Douglas considers this a possible key to the problem of depressions, but adds that the prospects of a complete theory are still remote. In spite of this warning one cannot refrain from feeling that a great step forward has been made, and the paper, with the resultant discussion, will not soon be forgotten by those who had the good fortune to be present.

British Floods and Droughts*

The indefatigable authors of this book have produced a volume which is of permanent value as a work of reference, if for nothing else. It contains descriptions of all the more important periods of excessive and deficient rainfall and of the floods and droughts which have been recorded in the British Isles, with such numerical details as are required for an appreciation of the intensity of the abnormalities. The period of time considered stretches back to the year A.D. 9, when a flood is recorded to have occurred in the Thames. Naturally the records of the floods and droughts of the earlier years are much less exact than those which are available for the last 70 years or so, thanks mainly to the public spirited action of numerous local authorities and private persons who have kept rainfall and other meteorological records and placed them at the disposal of the public. There are chapters on historic rains, floods and droughts, the droughts of the middle ages, the dry years of the eighteenth century, the rainy seasons of the 'seventies, the dry years 1887 and 1921, the year 1903 with two wet spells, the wet summer of 1924, the wet year 1927 and extremes of rainfall.

Meteorologists will, however, turn with greatest interest to Chapters I, VIII and XIV, dealing respectively with the causes of persistent rain, the causes of drought and cycles of weather. These are subjects in which Dr. Brooks has worked for many years, and the three chapters mentioned contain a brief account of much of his most recently published work. It is impossible not to admire the persistence with which he attacks these very difficult problems. Similar problems have been studied in India by distinguished meteorologists for a very long period of time, but it cannot be said that they have been solved for that country with sufficient accuracy to permit of really reliable forecasts of

1 ***By C. E. P. Brooks, D.Sc., and J. Glasspoole, M.Sc., Ph.D. Size $8\frac{1}{2} \times 5\frac{1}{2}$in. pp. 199. *Illus.* London : E. Benn Ltd. 1928. 10s. 6d. net.**

monsoon rainfall to be made. Owing to the regularity of the monsoons, it is generally considered that the preparation of seasonal forecasts for India is a less difficult problem than the corresponding problem for the British Isles. Here day to day weather is very variable owing to the continual advance and retreat across the country of "fronts" separating cold and warm air masses; and on many occasions—the recent cold spell is a good example—the British Isles are situated partly in one weather region and partly in another. A hundred miles or so may make all the difference between the conditions of a warm wet spell and those of a cold dry spell. It is therefore no disparagement to the authors to say that two of the three chapters referred to cannot be regarded as giving more than tentative indications of certain meteorological and hydrographical factors which have in the past been associated, more or less consistently, with prolonged rains and droughts in the British Isles. The authors use the word "cause" in these chapters more frequently than seems to be justified. They appear often to regard an event as "causing" another event, if there is a correlation between the two events, and if in addition, the former event precedes the latter in point of time. But more evidence than this is needed to prove that one event is the cause of another; both might well be products of some one or more entirely different event or events. Sometimes, however, the authors appear to require also some evidence of a physical connexion between the two events: for example, they are careful, in alluding to the relation between the abnormality of the Nile flood in summer and that of pressure in Iceland in the following winter and early spring, to say "it is not possible that the amount of water in the Nile should directly influence the subsequent weather over the British Isles." The reviewer would extend the cautious principle underlying this statement much further than the authors. He would affirm that it is doubtful whether it is legitimate to assume, as the authors do, a causal relation between variations in the ice carried by the Labrador current and subsequent variations in British weather, in the absence of any convincing proof that there is a chain of physical events connecting these two phenomena in a definitely progressive way, and that this chain actually operates in the manner suggested. It is of course easy to make criticisms, and probably very difficult to substantiate the reality of any physical chain of the kind described. Nevertheless the reviewer feels that until the physical connexions are placed on a much firmer foundation than they are at present, it is premature to speak of "causes," and better to be content with some non-committal word such as "associations." Such limitation of language would not in the least detract from the value which the work may have towards solving the problem of forecasting the weather of seasons.

The authors are to be congratulated on the production of a book which must have demanded the expenditure of not a little time and labour, and which is destined to be regarded as a standard work of reference.

R. Corless.

OFFICIAL PUBLICATION

The following publication has recently been issued:—

Professional Notes—

No. 51. Changes of zero in spirit thermometers. By W. F. Higgins, M.Sc., Physics Dept., National Physical Laboratory, and E. G. Bilham, B.Sc., A.R.C.S., D.I.C., Superintendent of Instruments, Meteorological Office (M.O. 273k).

In an attempt to explain the fall of reading noted over a period of some years in certain spirit thermometers, experiments have been carried out to ascertain the effect of the presence of acetone, in the filling liquid, upon the readings of spirit thermometers over a period of time. It is found that in spirit thermometers containing acetone a marked fall of reading is obtained in course of time when the thermometers are exposed to light. It is suggested that the effect is due to the contraction of the liquid consequent upon the formation of condensation products from the acetone under the influence of light. Acetone is known to be a common impurity in commercial methylated spirit, and it is shown that the use of this material either in the commercial or redistilled form should be avoided in the construction of spirit thermometers. No objection appears to attach to the use of pure ethyl alcohol, or acetone-free methyl alcohol, but a mixture of these two substances should be avoided.

Discussions at the Meteorological Office

February 11th—*Solar activity and long-period weather changes.* By H. H. Clayton (Smithsonian Misc. Coll., 78, No. 4, 1926).
Opener.—Mr. B. C. V. Oddie, B.Sc.

This paper was reviewed in the June, 1927, number of the *Meteorological Magazine*, page 115. It gave rise to an animated discussion, several speakers pointing out that solar influences could be readily discerned in pressure and temperature variations within the tropics, but that they could only play a minor rôle in temperate latitudes.

Mr. D. Brunt called attention to a table showing the relationships between the daily measurements of the solar constant at Mount Wilson (California) and Calama (Chile), which he considered to be the strongest argument yet put forward in favour

of the reality of day to day variations of solar radiation.

February 25th. *Relations between changes of atmospheric pressure and temperature. A contribution to the question of the "seat" of pressure variations.* By Bernhard Haurwitz (Leipzig, Geophys. Inst. der. Univ. Veröff 2nd Series, Bd. 3, H. 5, 1927, pp.267-336) (in German). *Opener*—Mr. L. Dods, B.Sc.

The paper is divided into three sections, a mathematical discussion of pressure-temperature relations, a statistical survey of a large number of ascents of registering balloons and a synoptic demonstration of temperature and mass changes on two occasions in 1911. The mathematical part was not discussed. For the statistical treatment the author investigates a large number of ascents during the years 1907—13, published in the *Reports of the International Commission for the Investigation of the Upper Air.* Those ascents are used which took place within about 24 hours of each other from the same places: 328 of these "pairs" have been taken from all over Europe. The pressure and temperature for each kilometre height have been found, and the pressure and temperature changes that have taken place within the 24 hours are arranged in various groups. One such group is the following:—

ΔP positive, ΔT positive ; ΔP negative, ΔT negative ;
ΔP positive, ΔT negative ; ΔP negative, ΔT positive.

where ΔP, ΔT are respectively the pressure change at the earth and the change in the mean temperature of the air layer next the earth in the 24 hours. Diagrams are given showing the algebraical means of the pressure and temperature changes at different heights in the atmosphere. The most interesting group is that for ΔP positive, ΔT positive. For this group the pressure increase at different heights is almost the same throughout the troposphere but falls off rapidly with increasing height in the stratosphere. The temperature change is positive in the troposphere and negative in the stratosphere. In connexion with this various writers have suggested that the development of the large warm anticyclones of our latitudes may be due to a burst of tropical air at great heights, bringing with it high pressure in the upper atmosphere and cold air in the stratosphere. The author comes to the conclusion that in 68 per cent. of the cases considered, the pressure change at the earth's surface is determined by the temperature changes in the troposphere and stratosphere, and in 18 per cent. by the temperature changes in the upper atmosphere, but that in 14 per cent. the observed pressure change cannot be explained by the temperature changes. The author does not attempt to point out the origin of the temperature changes.

Finally, in the last part of the paper two occasions in 1911 are dealt with synoptically, and a number of diagrams are given

showing temperature and mass changes at different heights, and the changes in the height of the troposphere and the temperature at the base of the stratosphere that have taken place in 24 hours

With regard to a point raised during the discussion as to whether the large winter anticyclones of Russia and Scandinavia extend to all heights of the atmosphere, the following ascents of registering balloons on December 7th, 1911 (the first case considered in the synoptic demonstration of simultaneous ascents), may be interesting. In that case an occluded trough of low pressure was over the British Isles, while a large intense anticyclone was centred over Russia. The ascents were not simultaneous, but took place within a few hours of each other.

	Trappes (Paris)		Pavlovsk		Ekaterinburg	
Height above Sea Level	p	t	p	t	p	t
	mb.	°F.	mb.	°F.	mb.	°F.
290 m.	*976	—	1001	20·1	1000	13·3
1 km.	895	36·0	915	21·9	915	25·7
2 ,,	788	28·9	804	12·6	805	21·4
3 ,,	695	23·0	*705	*6·1	709	13·3
4 ,,	611	12·7	619	3·9	621	1·0
5 ,,	536	2·1	541	- 7·2	544	- 10·3
6 ,,	468	- 9·6	472	- 20·2	475	- 20·7
7 ,,	407	- 23·8	409	- 34·1	412	- 34·8
8 ,,	353	- 36·4	353	- 49·9	356	- 49·0
9 ,,	304	- 56·2	304	- 63·0	305	- 62·7
10 ,,	260	- 74·0	260	- 68·4	261	- 75·8
11 ,,	221	- 73·8	223	- 62·0	223	- 85·0

* Values interpolated.

Unfortunately no ascent was made through the centre of the Russian anticyclone, but it is probable that an anticyclonic circulation was still maintained at 10km. The highest pressure (268mb.) at 10km., recorded in the ascents, was at Pavia (northern Italy), although in that region sea-level pressure was much lower than over Russia. The ascent at Trappes shows at all heights in the troposphere considerably higher temperatures than over the Russian anticyclone.

During the cold spell in the middle of last February, with a large intense " high " over Scandinavia, the cirrus motion over our Islands was persistently from the northwest or north over a southeasterly or southerly surface current. This suggests that in many cases the large cold, winter anticyclones of Scandinavia and Russia do not extend to great heights, pressure high up often being lower over them, than over the warm air currents experienced farther to the west. The problem requires much investigation.

L. Dods.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, February 20th, at 49, Cromwell Road, South Kensington, Sir Richard Gregory, LL.D., President, in the Chair.

The experiment of a short introductory talk on some topical subject, first tried at the meeting in January, was repeated, Capt. C. K. M. Douglas giving an account of the pressures and winds over Europe associated with the cold spell.

L. H. G. Dines, M.A.—The Baker automatic release for dropping the meteorograph from a registering balloon at a predetermined height.

In making soundings with free balloons it is sometimes desirable to limit the height to which the recording apparatus is carried before being dropped to earth again, in order to prevent its being lost in the sea. The instrument releases the balloon at a predetermined height. The setting of the device to ensure release at the desired height is determined by means of a special preliminary calibration.

C. K. M. Douglas, B.A.—Some aspects of surfaces of discontinuity.

The paper is based mainly on observations of upper air temperature and wind velocity through surfaces of discontinuity. It is shown that the typical sloping "polar front" surface is smoothed out through a layer about a kilometre thick, inversions being rare. The ordinary inversions with dry air above them are attributed to subsidence combined with turbulence up to a definite level. The general line of argument is that the more important pressure changes on weather maps are due mainly to large-scale horizontal movements at levels round about the base of the stratosphere, considered in conjunction with movements at lower levels. The changing pressure fields cause converging and diverging movements, which influence fronts and produce inversions where the air is subsiding. *See* also p. 34.

E. Kidson, O.B.E., D.Sc., and H. M. Treloar, B.Sc.—The rate of ascent of pilot balloons at Melbourne.

In pilot balloon observations at Melbourne the use of a range-finder in combination with a theodolite has enabled the balloon heights to be determined in the lower levels. The paper treats of the records for three and a half years with two ascents daily. The nature of the variation of the heights from those deduced by formula is discussed. It is concluded that atmospheric turbulence is the most important cause of departures from the normal rate of ascent. The effect of turbulence is to cause great variations in the height after a given interval from the release of the balloon. The greater the turbulence the greater is the mean height. The turbulence due to surface-heating of the air is more effective than wind turbulence in increasing the

rate of ascent in the lowest layers. This is attributed to the former having smaller dimensions. The heat turbulence is effective chiefly near the surface and in light winds. The view is also advanced that the rate of ascent is less in stable than in unstable air under the same conditions as to turbulence. An annual variation in the rate of ascent and relationships with wind velocity and weather types are claimed to be in accordance with the foregoing conclusions.

Correspondence

To the Editor, *The Meteorological Magazine*

Some Notes on the Frost

The following paragraphs are selected from a large number of letters containing details of the low temperatures and other weather conditions of February, which space prevents us from publishing in full :—

Rev. R. P. Dansey, Kentchurch Rectory, Hereford (12 miles west of Ross-on-Wye) :—

Feb.	"Grass" Min.	Shade Max.		Feb.	"Grass" Min.	Shade Max.
12th	—	26°	...	17th	–4°	27°
13th	–9°	26°	...	18th	–5°	35°
14th	–11°	23°	...	19th	17°	34°
15th	–9°	23°	...	20th	9°	37°
16th	—	30°	...			

In the rapid streams of the River Monnow so much ice formed in the bed over the stones and rocks that the river level was raised 6in. to a foot owing to the amount of space taken up by the ice. The river was low at the time, but it looked as if in spate though clear. In calm stretches it was normal height and was skatable for about five days.

I have only registered temperature below zero four times in forty years, February 6th and 7th, 1917, –1°; March 5th, 1909, and February 9th, 1895, –4°.

Mr. R. G. Sandeman, Dany Park, Crickhowell, South Wales :—

An exposed thermometer 22in. off the ground fell to at least –11°F. on the night of February 13th. On that night it was dangerous to touch any iron as the metal stuck to the hand and took the skin off. The river Usk is freezing in places and sheets of ice coming down.

Mr. C. P. Hooker, Wyeland House, Putsam, Hereford :—

Screen temperatures.

Feb.	Max.	Min.		Feb.	Max.	Min.
12th	30°	18°	...	16th	25°	15°
13th	25°	0°	...	17th	31°	5°
14th	29°	–1°	...	18th	30°	1°
15th	27°	–2°	...			

Mr. G. E. Dacey, 65, *Clarendon Road, London S.E.*13 :—

Screen temperatures.

Feb.	Max.	Min.		Feb.	Max.	Min.
12th	24°	14°	...	16th	27°	21°
13th	24°	11°	...	17th	25°	16°
14th	25°	13°	...	18th	33°	9°
15th	26°	6°	...	19th	31°	23°

Mr. L. C. W. Bonacina, 27, *Tanza Road, Hampstead*:—

The Rev. H. H. Breton has reported to me a depth of snow on February 16th of 3ft. undrifted near Buckfastleigh and of 6ft. undrifted higher up on Dartmoor. He also reports a great ice-storm (silver thaw called "ammil" on Dartmoor) on February 26th during the night.

A Curious Ice Structure

The photograph which forms the frontispiece of this number of the magazine, and which has kindly been sent by Mr. Basil Longley, of Crawley, Sussex, shows a curious effect of the frost on a bowl of water. Mr. Longley writes:—

"This ordinary tongue jar was placed out on a grass lawn at least 20ft. away from the nearest tree or obstacle on Sunday afternoon last (February 3rd), being full of water for birds. It was a great surprise to me, therefore, to see first thing on Monday morning what appeared to be an inverted icicle rising out of the centre of the bowl.

The only explanation that I can offer is that the water froze rapidly on top, and when the expansion took place underneath, the surface ice broke (this can be seen), and owing to the continuing pressure of the water expanding, it gradually oozed out freezing as it came. There was a tiny hole up the centre of the column which justifies this theory.

The temperature fell to 17°F. during the night and in the early part of the evening dropped very rapidly.

The photograph was taken by Mr. Lewis G. Ball, the local photographer."

A rough calculation shows that Mr. Longley's explanation is probably correct. The volume of the "inverted icicle" is about one-hundredth of the volume of the ice in the jar, while water expands by about nine-hundredths in the process of freezing.

Ice Crystals

While recently spending a holiday in the Bernese Oberland, I noticed on several occasions a thin veil of ice crystals enveloping both mountains and valleys, and causing a halo. On all the occasions (January 25th to 27th and February 12th to 14th) the temperature was very low, ranging from 10° to —20°F. Simultaneously with the ice crystal clouds there were often some

ordinary detached clouds of a short-lived character, and I have no doubt that these consisted of super-cooled water drops. The crystals were small but were large enough to be seen and felt. When they were sparsely scattered the visibility sometimes reached 10 miles. On one occasion the veil thickened to alto-stratus, and at a height of 7,000ft. the horizontal visibility of large objects was about $1\frac{1}{2}$ miles. I am inclined to regard this as typical of thin alto-stratus clouds with the sun just visible, since when flying I more than once saw the ground through a vertical thickness of over a mile of alto-stratus clouds, the total thickness of the clouds being much greater than this. On one occasion floating ice crystals developed from a shallow valley fog, which did not itself consist of crystals. The frequent occurrence of low ice crystal clouds in high latitudes has been noted by many observers, and the difficulty involved in fitting them into the existing cloud classification has often been commented on. I should like to express the personal opinion that all considerations of height should be abolished from the cloud classification, so as to allow clouds in the cirrus and alto-stratus groups to exist right down to sea level.

Even in the absence of ice crystals, very cold weather in the Alps is apt to be hazy, since air which is cold aloft is easily penetrated by convection. The perfect transparency of typical Alpine air is usually associated with the slowly descending air of anticyclones. This type of weather is fortunately very frequent, as one would expect from the mean isobaric distribution.

A good display of alto-cumulus castellatus clouds was observed on February 10th, and snow followed in six hours. Detached cirrus was first visible some hours earlier on the horizon, but considering that there had been nine practically cloudless days, the breakdown was unusually sudden.

C. K. M. Douglas.

On the morning of February 9th, 1929, there appeared on the "Hogs Back" road a phenomenon of, presumably, very rare occurrence. The weather was a little foggy, but very frosty. The frost was, however, disappearing under a gentle breeze and a rising temperature, whilst along the roadside and the gravel side-walk (in open country with fields on either side) for several hundred yards were scattered quantities of ice formations resembling thin strips of glass which might have been cut with a glazier's diamond. There were some rather small trees along the roadside at intervals averaging 50ft., and although the larger pieces of ice were found near the base of the trees, the formations were not limited to such places, but were regularly strewn in practically an unbroken stretch, the whole of the distance. Moreover, they were quite flat and not curved or

irregular as would have been expected had the formations fallen from the trees. They were regular in shape, differing only as regards length, being (1) rectangular, (2) of same width, (3) of same thickness. Their dimensions were approximately, breadth ¼in., thickness 1/12in. and varied from ½in. to 2½in. in length. The majority were approximately 1in. in length, but there were quite a number of pieces, usually together, of lengths above 1in. It would be interesting to know the cause of these formations, and whether this phenomenon has been witnessed on any previous occasion.

H. J. WELLER.

Guildford. March 7th, 1929.

A curious phenomenon occurred here this morning. I was on the Observatory Tower and noticed some "dancing-tinsel" effects in the sunshine like very fine broken shimmering silver wire—scintillating like long "sparks." Could this be the frozen water vapour in the air or frozen fog particles scintillating in the sunshine? I have never observed such a thing before. The tinsel-threads could not have been spider-web threads, as they were in the air a good distance from the tower, and 25 to 30ft. above the ground.

F. J. PARSONS.

County Observatory, Ross-on-Wye, Herefordshire. February 14th, 1929.

A phenomenon frequently observed in polar regions is a fall of ice crystals from a cloudless sky. A similar occurrence was noted here on the morning of February 14th. The fall commenced about 7h. 30m. G.M.T. and continued for two hours. At the commencement the sky was almost half-covered with strato-cumulus cloud at 4,000ft. This cloud gradually dispersed whilst moving from east to southeast of the station, and by 9h. the sky was cloudless. From 9h. to 9h. 30m. ice crystals continued to fall from a clear blue sky whose intensity appeared undiminished by the precipitation. A close examination showed their structure to be in the form of a central hub with six radiating spokes, the largest crystal being about 5 millimetres in diameter. They were sufficiently numerous to give the impression of slight snow. As far as can be ascertained the fall took place within at least a two mile radius.

At this period the station was situated in the very cold circulation around an anticyclone over north Scandinavia. The temperature at 7h. was only 9.6°F., but by 9h. 30m. had risen to 17.5°F. Upper winds showed a NE. to ENE. drift up to 3,000ft., backing gradually to N. at 8,000ft.; speed 10 to 20 miles per hour.

Precipitation in the form of ice crystals was also observed on February 13th, 16th and 26th under cloudy conditions.

W. H. BIGG.

South Farnborough. March 4th, 1929.

Pack Ice on the Maplin Sands

The Maplin Sands, which extend along the Essex coast between the estuaries of the Thames and the Crouch, form a very extensive area of nearly level firm sand when the tide is out. This morning the sands for about half a mile from high-water mark were covered with pack ice and brash to a depth of about a foot. A number of barges which were close in shore presented the appearance of being completely ice bound. The same phenomenon was to be seen along the foreshore at Southend and Westcliff although much less pronouncedly than at Shoeburyness.

C. E. Britton.

New Ranges, Shoeburyness. February 12th, 1929.

Air Temperatures in a Well

The writer made some observations of temperature at depths from the well-head to near the surface of the water from February 20th to 25th, a period of comparatively warm weather between the two great frosts of that month.

The well has a diameter of about 5 ft. and the depth to the surface of the water is 25ft., there being 5ft. of water. The well-head is 350ft., about, above mean sea level. It is not used, so that the air is seldom disturbed.

It would appear that the temperature at any depth is constant, as follows :—

Depth ft.	*Temp.* F.°
3	41
6	41-42
12	42-43
18	43
24	44

The external air temperature varied from 30° to 39°.

M. A. Carlisle Crowe.

Pye Hill, Finchampstead, Berks. March 1st, 1929.

Slight Rain with Low Humidity

Snow lay on Salt Island (surrounded by sea at high tide), Holyhead, from February 11th to 20th, 1929, and it was noted that snow lay down to high-water mark until the 19th.

On the 19th, 20th and 21st the humidity was below 80 per cent. generally becoming as low as 55 per cent. at times, the wind mainly between SE. and S., light to moderate and the visibility never exceeding 6 miles.

On the 20th there was slight rain at times, and on the 21st almost continuous rain until 19th, 7mm. falling between midnight and 19h. It is thought that the humidity of 55 per cent.

at 13h. on the 20th with intermittent slight rain and the rainy day of the 21st with humidity varying between 65 and 80 per cent. are worthy of note. H. L. PACE.

Salt Island, Holyhead, Anglesey. February 22nd, 1929.

Winter Thunderstorms

The annual census of winter thunder in the British Isles is being made for the last time during the present season. Before closing the work it is necessary to make special inquiries into the frequency of winter thunder in a number of areas from which insufficient data have been obtained during the past five years. It is very probable that the majority of these areas seldom experience a storm, but it is also possible that the shortage of data may be due to thinness of population : in either case definite evidence, negative or otherwise, is extremely necessary.

I shall be very grateful if any of your readers, resident for a number of years in any of the undermentioned areas, will be good enough to send me their estimate of the number of times thunder is heard in their district during the six winter months (October 1st to March 31st) on the average each year. Probably in some areas the frequency will be as low as once in three or four winters, or perhaps no winter thunder may be remembered ; in any case the actual experience of the observer will be extremely welcome.

In England and Wales the areas extend from 10 to 15 miles round the places, and for a similar distance on either side of lines joining the groups of places, specified below. In Scotland and Ireland areas are specified by counties :—

England and Wales.—Cornwall : Wadebridge-Boscastle. Devon and Somerset : Lynton-Exmoor-Minehead. Norfolk : Fakenham-Aylsham. Cheshire : Malpas-Nantwich. Lincolnshire : Brigg. Yorkshire : Pocklington-Kirkby Moorside-Guisboro'. Westmorland and Yorkshire Kirkby Lonsdale-Hawes-Brough. Cumberland : Cross Fell-Brampton. Northumberland : Rothbury-Wooler. Cardigan : Lampeter-Cardigan. Carmarthen and Brecknock : Llangadock-Brecon. Carnarvon, Denbigh and Merioneth : Llanberis-Ruthin-Bala.

Scotland.—Counties :—Bute, Ayr, southern Lanark and Peebles, northern Perth, northern Forfar and western Aberdeen, eastern Inverness, Sutherland and Caithness.

Ireland.—Counties :—Limerick, northern Tipperary and southern Galway, Wexford and southern Wicklow, Sligo, northern Roscommon, Longford, Cavan, Monaghan and Louth, western Tyrone and eastern Donegal, northern Antrim and southern Londonderry.

This inquiry is in no way intended to cast doubt on the records already received for these areas, but hopes to secure fuller information where it has not been possible to draw adequate conclusions. Records of thunderstorms are requested up to March 31st next as usual. S. MORRIS BOWER.

10, *Langley Terrace, Oakes, Huddersfield. February 21st,* 1929.

NOTES AND QUERIES

Thomas Gray Memorial Fund

The Council of the Royal Society of Arts announce that under the will of the late Thomas L. Gray, the Royal Society of Arts has been appointed residuary legatee of his estate for the purpose of founding a memorial to his father the late Thomas Gray, C.B., who was for many years Assistant Secretary to the Board of Trade (Marine Department). The objects of the Trust are "The advancement of the Science of Navigation and the Scientific and Educational Interests of the British Mercantile Marine."

The Council now offer the following prizes:—

(1) A prize of £150 to any person who may bring to their notice a valuable improvement in the Science or Practice of Navigation proposed or invented by himself in the years 1928 and 1929.

(2) A prize of £50 for an essay on the following subject:—"You are overtaken by a revolving storm. Discuss the handling of a low-powered steamer from the time of the first indication of the approach of the storm until the storm has passed, supposing the ship to be in (*a*) the safe semicircle, (*b*) the dangerous semicircle, and (*c*) the direct path of the storm's centre."

Competitors must send in their proofs of claim or essays not later than December 31st, 1929, to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.2.

The essays must be sent in under a motto, accompanied by a sealed envelope enclosing the author's name, which must on no account be written on the essay.

Review

Müller-Pouillets's *Lehrbuch der Physik*. Eleventh edition, fifth volume, first part. *Physik der Erde*. Edited by Alfred Wegener. Size $9\frac{1}{2} \times 6\frac{3}{4}$in. pp. xviii + 840. Brunswick, 1928.

The eleventh edition of Müller-Pouillet's *Lehrbuch der Physik* has a special interest as signalising in a sense the centenary of the work, for the two volumes of Pouillet's *Elements de physique et de météorologie* were first published in 1827, though Müller's translated and expanded version did not appear until 1842, and it was in 1856 that the two names were coupled on the title-page. The work has continued to grow with the years, and while meteorology is still dealt with at a length unusual in text-books of physics, a considerable part of the present half-volume of 830 pages deals with the new science of geophysics.

The first chapter, on meteorology, covering 168 pages, comes from the able pen of Professor H. von Ficker, and is written with an appropriate physical bias; thus long sections are devoted to the subjects of solar radiation, the applications of the physics of gases to atmospheric processes, and the circulation of water in

the atmosphere. The remaining sections of this chapter are:—The meteorological elements, their measurement and calculation; Atmospheric movements; The diurnal and annual periods of the meteorological elements; The average distribution of the meteorological elements in horizontal and vertical directions; Atmospheric disturbances. The second chapter by Professor A. Wegener (who also, after the death of Dr. O. Lummer in 1925, assumed the task of editing the whole volume) is a comprehensive discussion of Atmospheric Acoustics, including the phenomena and explanation of the outer zone of audibility. Wegener has also prepared the third chapter, on Optics of the Atmosphere, a very compact and useful summary. The phenomena are classified under the three headings of refraction, diffuse reflection and optical phenomena connected with the products of condensation. This chapter is remarkably well illustrated, with 58 figures in the text and three full-page plates in half tone.

Chapter 4, by H. Thorade, deals with the Physics of the Sea, including the physical peculiarities of sea water, the processes of warming and cooling of the oceans, ocean currents (mainly a discussion of the work of Ekman), waves and tides. The fifth chapter; the Physics of Glaciers, by H. Hess, contains some useful data on the physical characteristics of ice. This chapter is short; it might have been made longer with advantage by the inclusion of some reference to the inland ice sheets of Greenland and the Antarctic. Chapter 6, on Terrestrial Magnetism, by A. Nippoldt, is especially adequate from the instrumental side, and is also well illustrated by means of charts. G. Angenheister has contributed a short chapter on the Aurora (relatively short, for the 32 pages contain space for a great deal both of observation and of theory), while H. Benndorf and V. F. Hess have written the following very long chapter on Atmospheric Electricity, chiefly from the physical side. The last chapter, on the Mechanics and Thermodynamics of the Earth, was partly written by the late Prof. B. Gutenberg and was completed by Prof. E. Wiechert.

The death of Prof. Gutenberg, following on that of the first editor, delayed publication considerably, and has resulted in the different sections differing considerably in the degree to which recent work has been incorporated. For example, the section on Oceanography was completed before the return of the *Meteor;* and the rich harvest of this expedition has not found a place More serious from our point of view is the tendency to ignore the recent work of English meteorologists. The index does not contain the names of Simpson, Shaw, Gold, Dines or Chree—not that this is conclusive, for the index is decidedly incomplete, and Dr. Simpson's work on the mechanism of thunderstorms is in fact described on page 651. For a survey of the essentials of meteorology and geophysics however the book may be recommended to those who do not mind stiff reading. It is certainly

good value for the money, but the purchaser is recommended to spend the extra few shillings charged for the bound edition, as the book is so heavy that unbound copies would soon become tattered. It only remains to add that the printing is excellent and the abundant illustrations remarkably clear.

C. E. P. BROOKS.

News in Brief

The tenth Annual Soirée of the Meteorological Office Staff was held at the Portman Rooms on February 28th and was well attended by the staff and their friends. The function consisted of dancing interspersed with concert items, and amongst those who enjoyed a thoroughly sociable evening were the Director and the Assistant Directors.

The Eighth Annual Dinner of the Staff of the Meteorological Office at Shoeburyness was held at the Queen's Hotel, Westcliff, on February 16th. Mr. D. Brunt, Superintendent of Army Services, was the guest, and a number of past members of the staff were present. Following the dinner and the usual toasts, an entertainment consisting mostly of original items was enjoyed.

The Weather of February, 1929

In many parts of England February, 1929, will be remembered as the coldest February experienced since 1895: in Scotland the conditions were less extreme, while in western Ireland the mean temperature was slightly above normal. The month opened with mild unsettled weather and rain at times, 1·86in. fell at Fofanny, Co. Down, and 1·36in. at Patching Farm, Sussex, on the 2nd. On the 3rd, with the advance westward of the anticyclone centred over Germany, there was a general change to sunny conditions, especially in the south and east of England and the Channel Islands, over 8hrs. bright sunshine being enjoyed at several places, 8·7hrs. at Hastings on the 3rd and 8·7hrs. at Jersey on the 4th. During these four days, temperature rose in most parts to above 50°F. and reached 58°F. at Cambridge on the 1st, but after the 2nd night frosts became general. Subsequently pressure fell generally, the dull weather of the extreme northwest spread over the rest of the country, and there were heavy showers of rain, hail or sleet. Snow was reported from the Midlands on the 9th. Then the large intense anticyclone over northern Europe spread slowly southwestwards and there was a general fall in temperature over Great Britain as the easterly winds brought cold air from central and eastern Europe. On the 11th snow fell in many parts, and strong southeasterly winds and gales were reported from exposed places over the country generally; Beaufort force 9 (49 m.p.h.) occurring throughout the day at Wick. The winds decreased the next

day, but the intense cold* continued, and temperature remained below the freezing point day and night in many districts for about six days, except in the extreme west, which after about the 13th came under the influence of southwesterly winds, part of a depression over the Atlantic. In Great Britain snow lay in deep drifts in many parts, but the conditions were often sunny and precipitation was slight; 8·8hrs. of bright sunshine occurred at Bath on the 12th, and 8·6hrs. at Aspatria on the 14th. On the 20th the anticyclone over Scandinavia began to move southwards, and day temperatures in Great Britain rose considerably, though night frosts continued and there was much mist and fog. In Ireland a shallow secondary depression caused heavy rain on the 20th, 4·26in. falling at Kilmacthomas, Waterford, and 1·65in. at Fofanny, Co. Down. Day temperatures continued relatively high on the 22nd and 23rd, but on the 24th the depression to the west of the Bay of Biscay began to move eastwards. There was a renewal of east winds and cold conditions (though not so severe as earlier in the month) with further snow in Great Britain and eastern Ireland. Easterly gales were experienced in the south on the 27th, and quiet cold sunny weather generally on the 28th, 9·1hrs. bright sunshine being recorded at Bath on that day. The distribution of sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	66	+8	Valentia	49	−20
Aberdeen	37	−36	Liverpool	59	−9
Dublin	42	−31	Falmouth	55	−28
Birr Castle	32	−35	Kew	51	−9

The distribution of pressure over Europe during the month was highly abnormal. An intense anticyclone covered Scandinavia and Finland, the average being 1,025mb. along the whole west coast and exceeding 1,030mb. over the Gulf of Bothnia, where it was 20mb. above normal. From the coast of Norway pressure decreased rapidly to 1,003mb. over north-west Iceland, where it was only 2mb. above normal, but the lowest pressure was found over the North Atlantic, about 1,000 miles west of Ireland, where it averaged 1,002mb., 6mb. below normal Pressure was also relatively low over the Mediterranean, 1,012mb. at Rome, or 4mb. below normal. In place of the usual system of south-westerly winds across western and central Europe there were accordingly two currents of air, easterly winds over Germany, Switzerland and France, and southerly winds over western Ireland, the Faroes, Iceland and Spitsbergen. In the region of easterly winds temperature was abnormally low, 10°F. below normal at Stockholm and 18° below normal at Zürich, but in the region of southerly winds temperature was abnormally high, the excess reaching 20°F. at Spitsbergen,

* See p. 29

where the average temperature for the month was the same as at Zürich, normally nearly 40° warmer. Precipitation was deficient in the region of easterly winds—in western Gothaland it was only about 15 per cent. of the normal—while in the region of southerly winds it was above normal.

The worst conditions, briefly reported in the issue for February, occurred during the first half of the month. From the 1st to 5th a violent gale accompanied by snow swept over Constantinople, and on the 3rd snow was reported at Palermo in Sicily. Canals in Holland froze early in the month, and by the 12th parts of the rivers and some of the largest lakes were frozen over—the Elbe from Hamburg to Dresden, the Rhine and Lake Constance. Parts of the Baltic froze, and the Great and Little Belts and Copenhagen Sound were almost completely blocked on the 11th. On the 15th ice floes were floating on the Grand Canal at Venice. Conditions in Scandinavia continued severe until the end of the month, but on the 17th and 18th there was a marked rise of temperature in France, Germany, Switzerland and further south. Floods were reported from Bavaria, Macedonia and Thrace, and further heavy falls of snow in Jugo-Slavia again blocked the railway. In Germany and Switzerland there was a general thaw between the 22nd and 26th, but on the 28th cold northeasterly gales in Switzerland and France brought a return of the cold.

Heavy rain prevailed in Transjordan on the 20th. A violent storm swept across Beira (Portuguese East Africa) on the 3rd, and heavy rains in the neighbourhood on the following days caused several washaways on the Rhodesian railways.

Aided by the intense heat and high winds bush fires in New South Wales did much damage early in the month. On the 10th, however, floods occurred round Sydney, Gloucester and Wingham.

In the United States temperature was generally below normal except along the Pacific coast during the first and last week, and part of the Atlantic coast the other two weeks. Precipitation was mostly slight up to about the 21st, when there was a severe snowstorm over the eastern States.

The special message from Brazil states that the rainfall in the northern and central regions was very plentiful with 2·87in. and 3·03in. above normal respectively, while the distribution in the southern regions was irregular with 1·26in. above normal. Five anticyclones passed across the country and rainstorms were experienced in the extreme south. Crops were in good condition owing to the favourable weather. At Rio de Janeiro pressure was 2 mb. below normal and temperature 0.5°F. above normal.

Rainfall, February, 1929.—General Distribution

England and Wales	49	per cent. of the average 1881-1915.
Scotland...	54	
Ireland	129	
British Isles	67	

Rainfall: February, 1929: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square	·58	35	*Leics* .	Belvoir Castle	·50	30
Sur .	Reigate, The Knowle...	·45	22	*Rut* .	Ridlington	·57	...
Kent .	Tenterden, Ashenden...	1·00	51	*Linc* .	Boston, Skirbeck	·56	38
,, .	Folkestone, Boro. San.	·76	...	,, .	Lincoln, Sessions House	·79	54
,, .	Margate, Cliftonville...	·46	33	,, .	Skegness, Marine Gdns	·61	40
,, .	Sevenoaks, Speldhurst	·52	...	,, .	Louth, Westgate	·84	44
Sus .	Patching Farm	2·22	100	,, .	Brigg, Wrawby St. ...	·53	...
,, .	Brighton, Old Steyne	1·73	86	*Notts* .	Worksop, Hodsock ...	·51	33
,, .	Tottingworth Park ...	·93	40	*Derby* .	Derby, L. M. & S. Rly.	·44	27
Hants .	Ventnor, Roy. Nat. Hos.	1·17	70	,, .	Buxton, Devon Hos....	·85	23
,, .	Fordingbridge, Oaklnds	1·06	43	*Ches* .	Runcorn, Weston Pt.	1·08	58
,, .	Ovington Rectory	...	...	,, .	Nantwich, Dorfold Hall	·77	...
,, .	Sherborne St. John ...	·67	31	*Lancs* .	Manchester, Whit. Pk.	1·02	53
Berks .	Wellington College ...	·46	24	,, .	Stonyhurst College ...	1·01	30
,, .	Newbury, Greenham...	·77	35	,, .	Southport, Hesketh Pk	·93	44
Herts .	Benington House	·58	36	,, .	Lancaster, Strathspey	1·02	...
Bucks .	High Wycombe	1·19	64	*Yorks* .	Wath-upon-Dearne ...	·94	57
Oxf . .	Oxford, Mag. College	·53	33	,, .	Bradford, Lister Pk....	·73	31
Nor .	Pitsford, Sedgebrook...	·54	32	,, .	Oughtershaw Hall......	1·83	...
,, .	Oundle	·78	...	,, .	Wetherby, Ribston H.	·66	38
Beds .	Woburn, Crawley Mill	·63	43	,, .	Hull, Pearson Park ...	·90	54
Cam .	Cambridge, Bot. Gdns.	·48	38	,, .	Holme-on-Spalding ...	·67	...
Essex .	Chelmsford, County Lab	·45	30	,, .	West Witton, Ivy Ho.	·98	...
,, .	Lexden Hill House ...	·48	...	,, .	Felixkirk, Mt. St. John	1·11	66
Suff .	Hawkedon Rectory ...	·55	36	,, .	Pickering, Hungate ...	1·18	..
,, .	Haughley House	·36	...	,, .	Scarborough	1·32	79
Norf .	Norwich Eaton	·87	53	,, .	Middlesbrough	·55	42
,, .	Blakeney..................	...	...	,, .	Baldersdale, Hury Res.	·72	...
,, .	Little Dunham	·81	50	*Durh* .	Ushaw College	1·37	86
Wilts .	Devizes, Highclere......	·95	48	*Nor* .	Newcastle, Town Moor	·72	45
,, .	Bishops Cannings	1·02	48	,, .	Bellingham, Highgreen	1·32	...
Dor .	Evershot, Melbury Ho.	1·42	45	,, .	Lilburn Tower Gdns....	1·96	...
,, .	Creech Grange	1·86	...	*Cumb* .	Geltsdale...................	·60	...
,, .	Shaftesbury, Abbey Ho.	1·30	56	,, .	Carlisle, Scaleby Hall	·68	31
Devon .	Plymouth The Hoe ..	3·09	105	,, .	Borrowdale, Seathwaite	3·89	34
,, .	Polapit Tamar	1·52	47	,, .	Borrowdale, Rosthwaite	2.42	...
,, .	Ashburton, Druid Ho.	3·71	78	,, .	Keswick, High Hill ...	·82	...
,, .	Cullompton.......	1·88	68	*Glam* .	Cardiff, Ely P. Stn. ...	1·60	53
,, .	Sidmouth, Sidmount...	2·57	103	,, .	Treherbert, Tynywaun	2·91	...
,, .	Filleigh, Castle Hill ...	1·73	...	*Carm* .	Carmarthen Friary ...	1·49	40
,, .	Barnstaple N. Dev. Ath.	1·54	57	,, .	Llanwrda	1·73	40
Corn .	Redruth, Trewirgie ...	3·33	88	*Pemb* .	Haverfordwest, School	·98	...
,, .	Penzance, Morrab Gdn.	3·34	100	*Card* .	Aberystwyth	2·74	79
,, .	St. Austell, Trevarna...	4·30	100	,, .	Cardigan, County Sch.	1·86	...
Soms .	Chewton Mendip	1·54	45	*Brec* .	Crickhowell, Talymaes	·80	...
,, .	Long Ashton	1·41	...	*Rad* .	Birm W. W. Tyrmynydd	1·42	27
,, .	Street, Millfield ...	·99	..	*Mont* .	Lake Vyrnwy...........	1·30	29
Glos. .	Cirencester, Gwynfa ...	·68	30	*Denb* .	Llangynhafal	1·15	...
Here .	Ross, Birchlea............	1·21	60	*Mer* .	Dolgelly, Bryntirion...	1·85	42
,, .	Ledbury, Underdown	·68	37	*Carn* .	Llandudno	1·00	48
Salop .	Church Stretton.........	·66	30	,, .	Snowdon, L. Llydaw 9	4·05	...
,, .	Shifnal, Hatton Grange	·60	37	*Ang* .	Holyhead, Salt Island	2·69	110
Worc .	Ombersley, Holt Lock	·68	41	,, .	Lligwy......................	·84	...
,, .	Blockley	·65	...	*Isle of Man*			
War .	Farnborough	·55	27		Douglas, Boro' Cem....	1·99	62
,, .	Birminghm, Edgbaston	·56	33	*Guernsey*			
Leics .	Thornton Reservoir ...	·43	26		St. Peter P't. Grange Rd.	1·80	73

Rainfall: February, 1929: Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Wigt.	Stoneykirk, Ardwell Ho	2·27	87	*Suth.*	Loch More, Achfary	1·98	30
,,	Pt. William, Monreith	2·72	...	*Caith.*	Wick	·67	29
Kirk.	Carsphairn, Shiel.	3·57	...	*Ork.*	Pomona, Deerness	1·07	35
,,	Dumfries, Cargen	...	...	*Shet.*	Lerwick	1·96	62
Dumf.	Eskdalemuir Obs.	2·09	42	*Cork.*	Caheragh Rectory	8·70	...
Roxb.	Branxholm	1·36	52	,,	Dunmanway Rectory	9·91	170
Selk.	Ettrick Manse	...	...	,,	Ballinacurra	6·72	179
Peeb.	West Linton	1·23	...	,,	Glanmire, Lota Lo.	7·72	195
Berk.	Marchmont House	1·84	89	*Kerry.*	Valentia Obsy.	7·06	136
Hadd.	North Berwick Res.	1·24	48	,,	Gearahameen	8·10	...
Midl.	Edinburgh, Roy. Obs.	·85	53	,,	Killarney Asylum	4·82	92
Ayr.	Kilmarnock, Agric. C.	2·16	75	,,	Darrynane Abbey	6·62	143
,,	Girvan, Pinmore	2·68	63	*Wat.*	Waterford, Brook Lo.	8·67	266
Renf.	Glasgow, Queen's Pk.	1·61	55	*Tip.*	Nenagh, Cas. Lough	3·22	103
,,	Greenock, Prospect H.	2·77	49	,,	Roscrea, Timoney Park	3·03	...
Bute.	Rothesay, Ardencraig	3·59	90	,,	Cashel, Ballinamona	3·71	116
,,	Dougarie Lodge	3·17	...	*Lim.*	Foynes, Coolnanes	3·66	115
Arg.	Ardgour House	2·97	...	,,	Castleconnel Rec.	3·02	...
,,	Manse of Glenorchy	2·32	...	*Clare.*	Inagh, Mount Callan	4·68	...
,,	Oban	2·20	...	,,	Broadford, Hurdlest'n.	3·62	...
,,	Poltalloch	2·13	49	*Wexf.*	Newtownbarry	6·90	...
,,	Inveraray Castle	2·52	37	,,	Gorey, Courtown Ho	6·07	216
,,	Islay, Eallabus	2·78	66	*Kilk.*	Kilkenny Castle	3·22	127
,,	Mull Benmore	...	...	*Wic.*	Rathnew, Clonmannon	4·00	...
,,	Tiree	3·16	...	*Carl.*	Hacketstown Rectory	4·22	140
Kinr.	Loch Leven Sluice	2·05	73	*QCo.*	Blandsfort House	...	...
Perth.	Loch Dhu	3·50	47	,,	Mountmellick	3·73	...
,,	Balquhidder, Stronvar	1·93	...	*KCo.*	Birr Castle	3·24	141
,,	Crieff, Strathearn Hyd.	2·81	80	*Dubl.*	Dublin, FitzWm. Sq	1·91	210
,,	Blair Castle Gardens	1·75	63	,,	Balbriggan, Ardgillan.	4·13	...
,,	Dalnaspidal Lodge	3·34	61	*Me'th.*	Beaupare, St. Cloud	3·06	...
Forf.	Kettins School	1·85	87	,,	Kells, Headfort	...	...
,,	Dundee, E. Necropolis	1·92	102	*W.M.*	Moate, Coolatore	4·04	141
,,	Pearsie House	2·44	...	,,	Mullingar, Belvedere	3·50	126
,,	Montrose, Sunnyside	2·05	111	*Long.*	Castle Forbes Gdns	3·89	136
Aber.	Braemar, Bank	1·09	38	*Gal.*	Ballynahinch Castle	6·64	130
,,	Logie Coldstone Sch.	1·39	67	,,	Galway, Grammar Sch.	3·41	...
,,	Aberdeen, King's Coll.	1·72	84	*Mayo.*	Mallaranny	4·03	...
,,	Fyvie Castle	3·20	...	,,	Westport House	3·84	97
Mor.	Gordon Castle	·72	37	,,	Delphi Lodge	7·67	...
,,	Grantown-on-Spey	·35	17	*Sligo.*	Markree Obsy	3·15	90
Na.	Nairn, Delnies	·42	23	*Cav'n.*	Belturbet, Cloverhill	2·98	114
Inv.	Kingussie, The Birches	·81	...	*Ferm.*	Enniskillen, Portora	3·07	...
,,	Loch Quoich, Loan	3·40	...	*Arm.*	Armagh Obsy	2·26	102
,,	Glenquoich	2·94	29	*Down.*	Fofanny Reservoir	8·79	...
,,	Inverness, Culduthel R.	·35	...	,,	Seaforde	4·09	134
,,	Arisaig, Faire-na-Squir	1·02	...	,,	Donaghadee, C. Stn	2·61	113
,,	Fort William	2·10	...	,,	Banbridge, Milltown	1·90	91
,,	Skye, Dunvegan	2·04	...	*Antr.*	Belfast, Cavehill Rd	3·72	...
R & C.	Alness, Ardross Cas.	·65	20	,,	Glenarm Castle	3·49	...
,,	Ullapool	·88	...	,,	Ballymena, Harryville	3·24	100
,,	Torridon, Bendamph	1·54	19	*Lon.*	Londonderry, Creggan	2·35	74
,,	Achnashellach	1·40	...	*Tyr.*	Donaghmore	4·29	...
,,	Stornoway	1·44	32	,,	Omagh, Edenfel	3·04	102
Suth.	Lairg	·74	...	*Don.*	Malin Head	1·72	71
,,	Tongue	·91	26	,,	Dunfanaghy	2·59	...
,,	Melvich	·76	25	,,	Killybegs, Rockmount.	4·54	91

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, September, 1928.

STATIONS	PRESSURE		TEMPERATURE							Rela-tive Humi-dity.	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean			Am'nt	Diff. from Normal	Days	Hours per day	Per-cent-age of possi-ble
			Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb							
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	in.	in.			
London, Kew Obsy.	1020·7	+ 3·3	80	35	65·5	46·6	56·1	− 1·0	48·5	92	6·4	1·03	− 0·84	6	6·7	53
Gibraltar	1015·6	− 1·7	88	62	81·1	68·1	74·6	+ 2·1	67·0	84	5·8	2·69	+ 1·30	8	..	..
Malta	1017·1	+ 0·2	87	65	82·0	71·3	76·7	+ 0.7	71·0	77	3·7	2·20	+ 0·93	6	9·4	76
St. Helena	1015·5	+ 2·2	62	51	60·0	53·6	56·8	− 1·1	54·3	93	9·8	2·13	− 0·89	19	..	..
Sierra Leone	1014·1	+ 1·9	87	69	83·1	72·4	77·7	− 1·4	74·9	83	8·3	30·43	+ 1·95	25	..	..
Lagos, Nigeria	1010·9	− 1·9	83	70	81·4	73·9	77·7	− 0·7	74·7	87	7·1	5·60	+ 0·34	17	..	..
Kaduna, Nigeria	1015·3	+ 2·5	90	..	84·7	..	..	..	71·3	84	..	9·71	− 1·78	18	..	..
Zomba, Nyasaland	1013·4	− 0·3	88	54	81·2	60·9	71·1	+ 1·6	..	54	2·6	0·00	− 0·34	0	..	..
Salisbury, Rhodesia	1010·0	− 1·6	94	45	82·0	54·9	68·5	+ 2·1	56·4	42	1·6	0·16	− 0·10	1	9·4	78
Cape Town	1019·7	+ 0·6	79	40	63·6	49·2	56·4	− 1·5	50·7	85	5·2	3·16	+ 0·89	15	..	..
Johannesburg	1016·7	− 1·6	79	31	69·1	46·3	57·7	− 1·7	46·7	54	3·3	0·80	− 0·16	8	8·9	75
Mauritius	1020·5	+ 0·3	79	58	75·7	63·0	69·3	− 0·8	65·3	68	6·8	1·42	+ 0·12	18	7·6	63
Bloemfontein	..	..	84	26	68·9	42·2	55·5	− 3·6	44·9	54	3·2	0·25	− 0·65	3	..	..
Calcutta, Alipore Obsy.	1004·6	+ 0·1	93	77	90·7	79·6	85·1	+ 2·1	80·2	89	7·2	8·72	− 1·15	13*	..	..
Bombay	1008·3	+ 0·3	87	72	84·9	75·1	80·0	− 0·8	75·8	88	7·6	9·91	− 0·77	22*	..	..
Madras	1006·0	− 0·5	100	93	93·4	77·4	85·4	+ 0·3	76·7	78	6·6	8·18	+ 3·19	16*	..	..
Colombo, Ceylon	1010·2	+ 0·2	89	75	87·2	77·8	82·5	+ 1·6	76·9	73	7·0	1·44	− 4·78	16	7·9	65
Hongkong	1006·4	− 2·0	91	72	86·2	77·9	82·1	+ 1·1	75·4	72	6·1	3·91	− 6·08	9	6·7	54
Sandakan	..	..	91	71	89·0	74·2	81·6	− 0·1	77·4	82	..	10·06	+ 0·67	15	..	..
Sydney	1010·9	− 5·1	89	48	73·6	53·1	63·3	+ 4·1	55·4	53	4·0	0·20	− 2·69	6	8·4	71
Melbourne	1008·8	− 7·0	89	40	67·1	49·1	58·1	+ 4·0	51·3	59	6·6	1·13	− 1·28	15	6·5	48
Adelaide	1011·8	− 5·5	90	44	70·1	50·3	60·2	+ 3·1	52·6	55	5·6	1·81	− 0·23	10	6·1	52
Perth, W. Australia	1015·5	− 2·4	73	44	64·8	51·9	58·3	0·0	54·6	70	7·2	5·04	+ 1·64	20	6·1	52
Coolgardie	1014·3	− 2·8	88	36	72·2	46·0	59·1	+ 0·5	50·3	49	3·2	0·38	− 0·23	5	..	..
Brisbane	1015·0	− 2·3	86	47	78·6	55·9	67·3	+ 2·0	60·0	60	1·9	0·78	− 1·27	2	9·8	82
Hobart, Tasmania	998·6	−12·1	76	33	58·4	44·0	51·2	+ 0·4	45·5	61	7·2	4·47	+ 2·34	26	6·1	52
Wellington, N.Z.	1004·7	− 9·9	63	38	55·8	44·6	50·2	− 1·4	47·2	70	6·0	3·31	− 0·66	15	5·8	49
Suva, Fiji	1014·0	− 0·3	90	65	81·6	70·5	76·1	+ 1·6	71·6	76	7·1	4·15	− 2·83	15	5·8	48
Apia, Samoa	1012·5	+ 0·4	86	71	84·3	74·3	79·3	+ 1·1	76·6	79	5·1	8·03	+ 2·91	20	7·2	60
Kingston, Jamaica	1011·9	− 0·3	90	69	87·8	73·4	80·6	− 0·9	73·1	88	5·2	3·12	− 0·91	10	7·0	57
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Toronto	1016·2	− 1·6	80	33	66·6	48·8	57·7	− 1·5	51·5	80	4·3	2·85	− 0·33	13	7·0	56
Winnipeg	1014·3	− 0·5	81	29	64·8	42·7	53·7	+ 0·3	42·7	85	4·4	0·64	− 1·64	6	6·1	48
St. John, N.B.	1017·6	+ 0·1	73	37	61·4	48·2	54·8	− 1·1	52·0	81	6·4	4.90	+ 1·16	13	5·4	43
Victoria, B.C.	1017·1	+ 0·6	82	46	63·4	49·8	56·6	+ 1·0	52·4	76	3·7	0·45	− 1·56	5	7·5	60

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

28.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	80	4·3	2·83	—	0·33	13	7·0	56
Winnipeg	1014·3	— 0·5	81	29	64·8	42·7	53·7	+ 0·3	42·7	85	4·4	0·64	—	1·64	6	6·1	48
St. John, N.B.	1017·6	+ 0·1	73	37	61·4	48·2	54·8	— 1·1	52·0	81	6·4	4·90	+	1·16	13	5·4	43
Victoria, B.C.	1017·1	+ 0·6	82	46	63·4	49·8	56·6	+ 1·0	52·4	76	3·7	0·45	—	1·56	5	7·5	60

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.